



2003 AFCEE Technology Transfer Workshop

San Antonio, Texas

Promoting Readiness through Environmental Stewardship

Biowall at Altus AFB OK

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HQ AFCEE/ERD
26 Feb 2003**



Acknowledgements

- **Altus AFB**
 - **Mr. Dan Staton and Mr. Dewy Cooper**
- **HQ AFCEE/ERS**
 - **Mr. James Gonzales**
- **Mitretek**
 - **Mr. Patrick Haas**
- **Parsons**
 - **Mr. Bruce Henry**



Altus Projects

- **1996: Natural Attenuation Study (SWMU 7)**
 - **Resampling and report update in April 1999**
 - **Site Characterization, geochemical profiling, focused feasibility assessment, long-term monitoring**
- **2001: Request for assistance by AETC/CEV**
 - **Mobilize resources, projects, technologies, expertise**

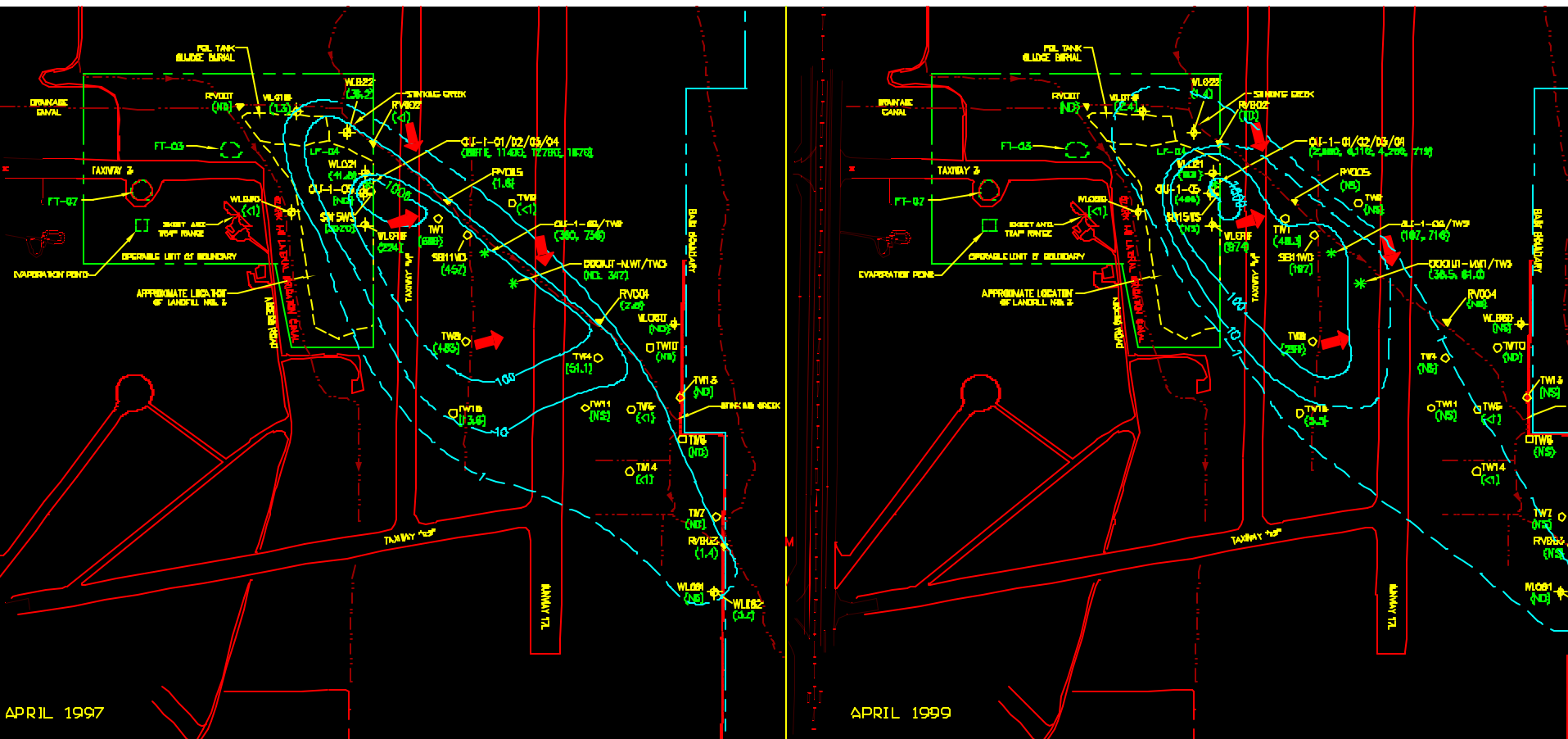


Altus Projects

- **2002: Bark Mulch Biowall (SWMU 7)**
 - **Site characterization**
 - **geochemical profiling**
 - **substrate emplacement cost and performance**
 - **enhanced bioremediation performance**



Natural Attenuation Study



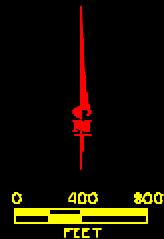
LEGEND

- ▼ SURFACE WATER/SEDIMENT SAMPLING LOCATION (13.6)
- ⊕ MONITORING WELL LOCATION (NS)
- MONITORING POINT LOCATION (ND)
- * WELL CLUSTER
- SURFACE WATER
- LINE OF EQUAL TCE CONCENTRATION IN SHALLOW GROUNDWATER ($\mu\text{g/L}$) (DASHED WHERE INFERRED)
- GROUNDWATER FLOW DIRECTION
- TCE CONCENTRATION ($\mu\text{g/L}$)
- NOT SAMPLED
- NOT DETECTED AT OR ABOVE LABORATORY DETECTION LIMITS

FIGURE 3
DISTRIBUTION OF TCE
IN SHALLOW GROUNDWATER
AND SURFACE WATER

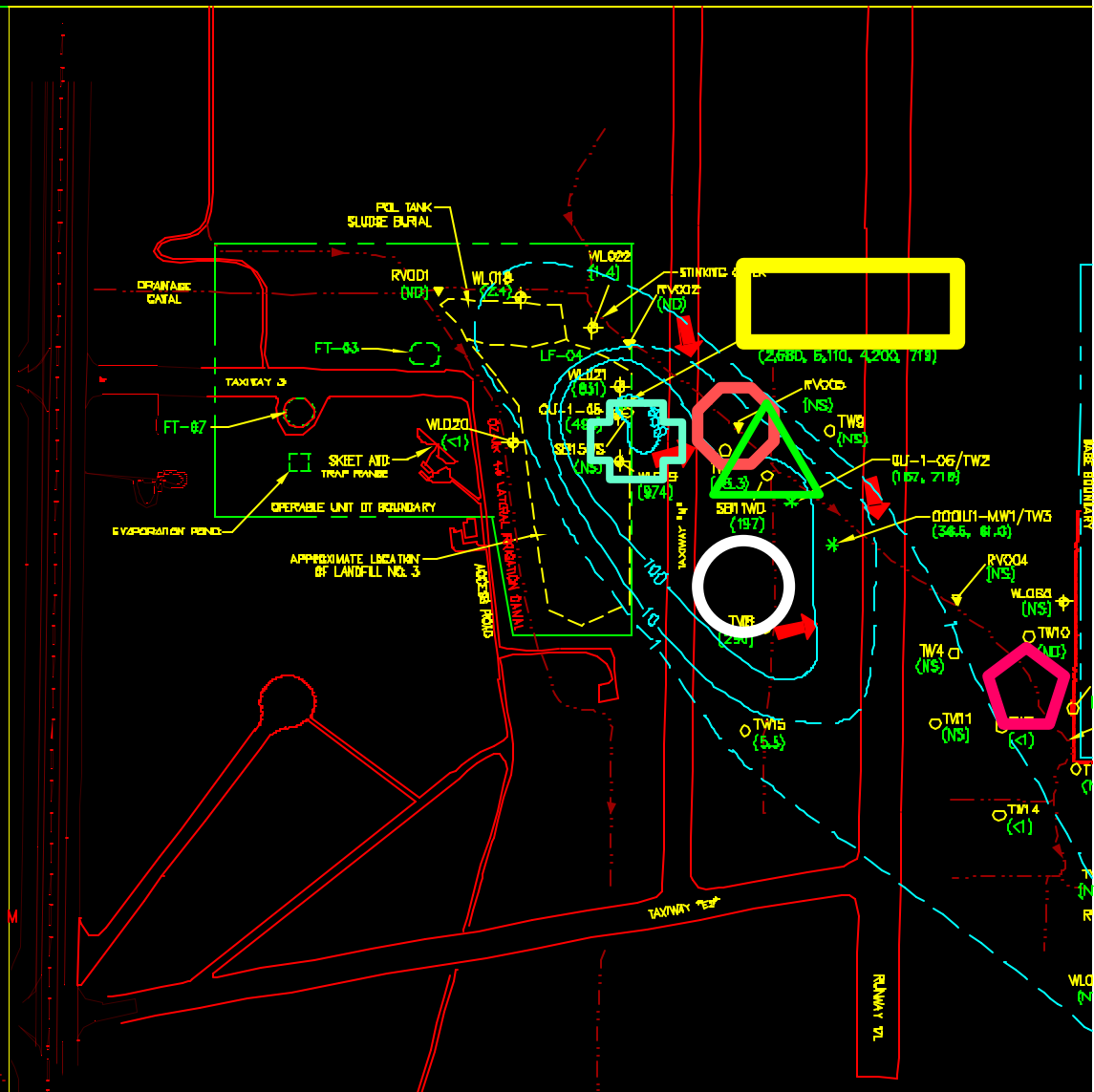
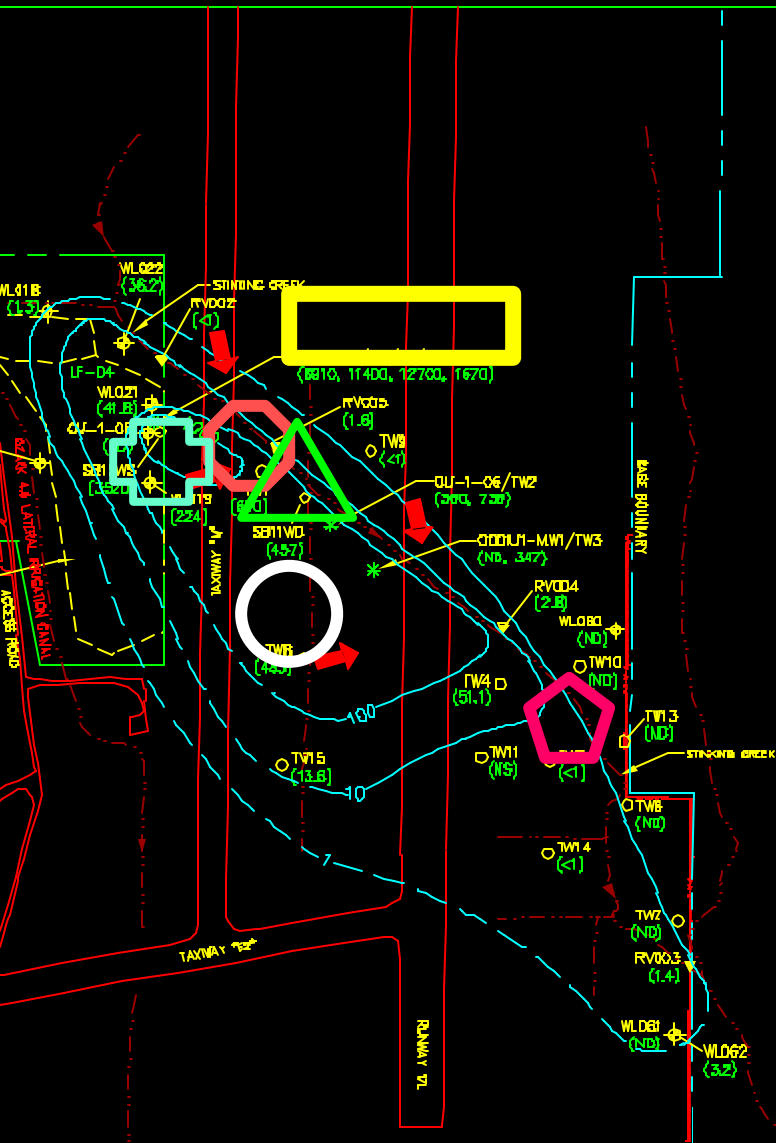
DU1
RNA TS Addendum
Altus AFB, Oklahoma

PARSONS
ENGINEERING SCIENCE, INC.
Denver, Colorado



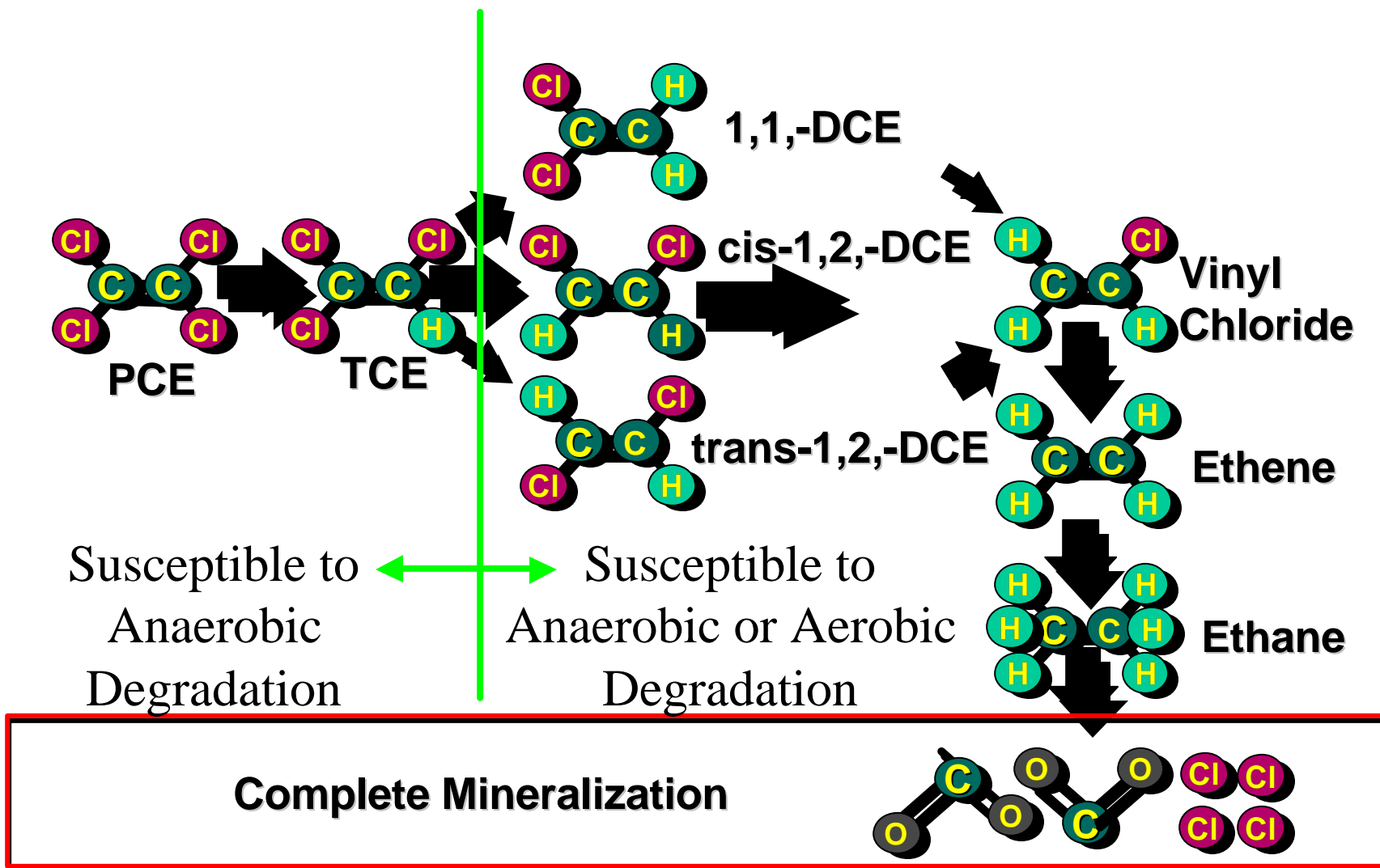
SWMU 7 Natural Attenuation Study

April 1997 vs. April 1999



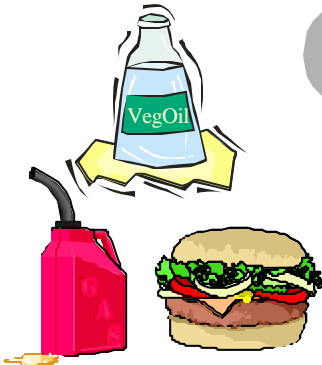


Anaerobic Reductive Dehalogenation of Chlorinated Ethenes

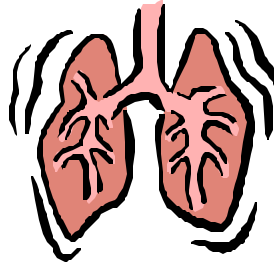




Use as Primary Growth Substrate



Electron
Donor
(food)



Electron
Acceptor
(something
to breath)
 $[O_2, NO_3^-,$
 $SO_4^{2-},$
 $Fe(III), CO_2,$
Solvents]



Metabolic
Byproducts
 $[Fe(II), CH_4,$
 $CO_2,$
Alkalinity, $Cl^-]$



Energy



Bark Mulch -low cost carbon source

- **Generally, trenched into place**
 - **passive reactive barrier**
 - **limited by depth**
 - **low O&M**
- **Surface Amendment**
 - **passive percolation of sustrate**
- **Slow released, long lasting**
- **Inexpensive or free**
- **Complex substrate**





Altus SWMU 7 Mulch Biowall

- Trench installed in June 2002
- 455 feet long by 24 feet deep by 1.5 feet wide
- Approximately 300 yd³ tree mulch, 60 yd³ cotton gin compost, and 265 yd³ sand
- Monitoring well networked installed and sampled in July 2002 (4 weeks after installation)

STINKING CREEK



LF-04

PERMEABLE REACTIVE BIOWALL

PES-MP-1 through PES-MP-5

PES-MP-6 through PES-MP-10

BASE BOUNDARY

OU-1-01/02/03/04

WL524

WL566

OU-1-05

EW-04

WL590

WL591

TW-01

WL019

TW-02

R23

WL527

WL528

APPROXIMATE LOCATION
OF LANDFILL NO. 3

WL565 WL564

TAXIWAY "M"

WL455

WL454

OU-1-06

WL453

OU-1-MW7

WL457

WL456

TW8

TW4

TW10

WL458

WL459

TW13

CH002



Preparing Bark Mulch



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Preparing Bark Mulch



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Preparing Bark Mulch



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Hazards



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Altus Mulch Biowall Installation



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Altus Mulch Biowall Installation



Promoting Readiness through Environmental Stewardship



Preliminary Results at 4 Weeks

<u>Upgradient</u>	<u>Biowall (MP-01) at 4 wks</u>	<u>Positive Indicator</u>
DO: <0.1 to 4.5 mg/L	DO: <0.1 mg/L	<input checked="" type="checkbox"/>
ORP: 20 to 107 mV	ORP: -365 mV	<input checked="" type="checkbox"/>
Sulfate: 1,600 to 2,200 mg/L	Sulfate: 410 mg/L	<input checked="" type="checkbox"/>
Methane: <1 mg/L	Methane: 8.8 mg/L	<input checked="" type="checkbox"/>
TOC: <10 mg/L	TOC: 2,800 mg/L	<input checked="" type="checkbox"/>
	Total VFAs: 960 mg/L	<input checked="" type="checkbox"/>
TCE (6,200 ppb) > DCE (850 ppb) at well OU-1-01	DCE (640 ppb) > TCE (48 ppb)	<input checked="" type="checkbox"/>
(Note: upgradient of MP-01)	No VC detected	<input checked="" type="checkbox"/>



Preliminary Results at 3 Months

<u>Upgradient</u>	<u>Biowall (MP-01) at 4 wks</u>	<u>Positive Indicator</u>
DO: <0.1 to 4.5 mg/L	DO: <0.1 mg/L	<input checked="" type="checkbox"/>
ORP: 20 to 107 mV	ORP: -212 mV	<input checked="" type="checkbox"/>
Sulfate: 1,600 to 2,200 mg/L	Sulfate: 17 mg/L	<input checked="" type="checkbox"/>
Methane: <1 mg/L	Methane: 7.0 mg/L	<input checked="" type="checkbox"/>
TOC: <10 mg/L	TOC: 380 mg/L	<input checked="" type="checkbox"/>
TCE (6,200 ppb) > DCE (850 ppb) at well OU-1-01	Total VFAs: 8 mg/L	<input checked="" type="checkbox"/>
(Note: upgradient of MP-01)	DCE (480 ppb) > TCE (<1 ppb)	<input checked="" type="checkbox"/>
	No VC detected	<input checked="" type="checkbox"/>



Projected Cost of Technology

- **Mulch: Free (if generated on-site) or \$15/yd³**
- **Biowall Installation: \$140-\$360/linear foot**
 - Includes all labor, trencher, sand fill, back-hoe, ect.
 - Highly sensitive to economies of scale
- **Additional Costs: Monitoring wells, analytical costs**



Altus Mulch Biowall Summary

- **Highly reducing conditions produced**
 - **Suitable for reductive dechlorination induced within and immediately downgradient of the biowall**
 - **Competing electron acceptors (DO, sulfate, etc.) rapidly depleted**
- **Elevated levels of dissolved organic carbon**
- **Elevated metabolic acids indicates substantial microbial growth**



Altus Mulch Biowall Summary

- **Rapid and significant degradation of TCE to DCE**
 - **>90% reductions in TCE within biowall in first 4 weeks**
 - **TCE less than 6 ppb within biowall at 3 months**
- **No accumulation of VC**



Questions



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